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ABNORMAL ENLARGEMENT OF PEAS FROM PLANTS AFFECTED WITH ROOT-ROT

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BULLETIN No. 621

ABNORMAL ENLARGEMENT OF PEAS FROM PLANTS AFFECTED WITH ROOT-ROT

J. G. HORSFALL AND Z. I. KERTESZ

ABSTRACT

Since a study of diseased organs sometimes throws light on their characteristics and functions, the root-rot complex caused by a group of micro-organisms has been used as an experimental approach to an analysis of quality in peas. That peas on diseased plants grow larger than peas of equal age and history on normal plants has been proved by several methods in investigations extending over two seasons. This fact is of considerable importance in view of the frequent correlation between big peas, diseased peas, and poor peas.

The abnormal enlargement of the peas on diseased plants may be correlated somewhat with a more rapid growth of the peas at the expense of the vines. It is not due to an earlier blooming of the plants, because even tho they bloom on the same date, the peas on diseased plants are larger than those on healthy plants. The blooming rate is somewhat slower for plants affected with root-rot than for normal plants, altho the growth rate of the peas themselves is undoubtedly faster on the diseased plants.

INTRODUCTION

Recently, agricultural research, particularly at this Station, has tended more and more to emphasize the quality of farm products rather than the production of larger quantities, thus harmonizing the needs of the consumer with those of the producer. This has been the natural reaction from the earlier emphasis upon quantity production. The call now is not to make two blades of grass grow where only one grew before, but to make a better blade of grass grow where an inferior blade grew before. At any time, but particularly when prices are deflated, the production of high quality goods is paramount.

It was for this reason that studies on the quality of vegetables and fruits were started in 1929 involving the cooperation of several Divisions of this Station. The quality of cannery peas was taken as one of the first projects in this series of studies,[1] but it was soon re-

[1]Sayre, C. B., Willaman, J. J., and Kertesz, Z. I. Factors affecting the quality of commercial canning peas. *New York State Agr. Exp. Sta. Tech. Bul. No. 176. 1931.*

alized that the definition of quality was most difficult. During several seasons efforts were made by chemical and mechanical means to find differences in quality between different lots of peas and thus to analyze that elusive factor.

The conclusion was soon reached that the differences in quality between the various lots of peas chosen were too small to be detected with ease, either mechanically (by crushing) or chemically. It was easy to distinguish between young peas and old peas, for example, but all the methods tried failed to give a clear picture as to just what really constitutes quality in peas.

Reasoning by analogy with animal physiology, where the normal characteristics and functions of glands and organs have been deduced from observations on these same structures when they were diseased, it occurred to the authors in 1931 to determine the effect of root-rot on the physiology and quality of peas—a point of considerable interest to plant pathologists as well as to chemists. It seemed that if peas grown under normal conditions were compared with peas from the same field which were infected with root-rot, differences might be found which would give a point of attack as regards mechanical and chemical variations between grades of peas of equal age and history. For this reason studies were undertaken to learn the effect of root-rot on the quality of peas, the preliminary results of which have been presented elsewhere.[2] These studies proved to be not only rather fruitful in showing a new approach to the determination of mechanical and chemical characteristics of quality in peas, but also resulted in some observations of physiological and practical interest.

It was observed in 1931, and confirmed in 1932, for example, that peas harvested from root-rot-affected plants were bigger during the early and middle part of the ripening period than those from healthy plants. Since peas from diseased vines are big peas and since peas bigger than average are frequently poor peas, it seemed desirable to investigate the abnormal enlargement of diseased peas. Accordingly, during the 1932 season, elaborate physiological and chemical studies were made of the abnormal enlargement of Perfection peas from root-rot-affected vines. It is the purpose of this bulletin to establish the fact of abnormal enlargement of the diseased peas by various methods and to mention briefly certain factors observed that may bear on its explanation. Also, this bulletin deals with the physiological observa-

[2]Horsfall, J. G., Kertesz, Z. I., and Green, E. L. Some effects of root-rot on the physiology of peas. *Jour. Agr. Res.*, **44**, *833-848. 1932.*

tions that were made, the results of the chemical investigations of this question being reported elsewhere.

MATERIALS AND METHODS

The method for collecting the pea samples used in 1931 has been described by Horsfall, Kertesz, and Green.[3] In brief it may be said that 3-kg samples of obviously diseased plants were chosen at intervals from contiguous, typically yellowed areas in a field. Control samples of the same size were obtained from normal-looking plants free from discoloration in the same field. It must be said, however, that a small amount of infection could be detected all over the field, but since the control samples consisted of disease-free or nearly disease-free plants they were called normal.

During 1932 an attempt was made to obtain more nearly disease-free plants for comparison than were available in 1931. Accordingly, an area of land 18 by 200 feet in size on the Station farm that had not grown peas for at least 25 years was chosen for the plats. In order to obtain diseased peas on this soil, one-half of it at the lower end of a slight slope was artificially contaminated during late summer of 1931 with several wagon loads of soil from a field naturally infested with pea root-rotting fungi. All the 1932 samples were obtained from this field.[4]

On April 20, 1932, Perfection peas, a popular canning variety, were planted on this area in 6-inch rows with a grain drill in the usual way at the rate of 5 bushels per acre. Since ideal germinating conditions prevailed, the stand was not affected by the inoculum. Every week during the entire season 50-plant samples composed of 10 plants from five different places were dug, roots and all, from each area.

These weekly 50-plant samples were classified into four groups based upon the severity of the infection. From this classification was calculated an index of infection according to the method used by Köck.[5] These samples gave an unfolding picture of root disease

[3] *Loc. cit.*

[4] The following list of fungi were isolated from plants growing in the infested part of this field: *Ascochyta pinodella* L. K. Jones, *Epicoccum neglectum* Desm. *Fusarium* spp., *Fusarium martii* var. *pisi* F. R. Jones, *Mycosphaerella pinodes* (B. and Blox) Stone, *Pythium salpingophorum* Drechs. (?), *Pythium* spp., *Rhizoctonia solani* Kuhn (normal strain) and *Rhizoctonia solani* Kuhn (strain with almost white hyphae). *Rhizoctonia solani* seemed to be very largely responsible for the malady in 1932, whereas *Pythium* spp. probably was the most important pathogene in 1931.

[5] Köck, G. Über das Verhalten der einzelnen Apfelsorten gegenüber dem Apfelmehltau. *Fortsch. Landw.*, **2**, *585–586. 1927.* Also abstracted in *Rev. Appl. Mycol.*, **7**, *177. 1928.*

development which showed that the peas on the normal area were not perfectly disease free, but that they were markedly less affected than those from the infested area. The peas from the infested area were not as badly diseased as had been hoped because weather conditions were not as conducive to root-rot development in 1932 as in 1931.

Early in June, before blooming began, three separate square-yard plats were marked off in each area and the number of plants in each determined. Then, during the entire blooming period, the blossoms appearing each day in each plat were counted and tagged with colored strings—each color representing a single day. Thus the effect of the disease on blooming could be ascertained. Also, this method gave peas of different known ages that were useful in other studies later in the season.

Beginning just as soon as any of the pods showed peas, samples of plants were pulled before 8 a. m. on alternate days from contiguous 1-yard-wide strips across the narrow way of the normal and infested areas. Since the area was 6 yards wide, this gave samples of about 400 plants from 6 square yards of ground. The plants were broken off at the ground line, counted, and brought into the laboratory, where the pods were removed by hand and weighed. All the pods on the sample were then counted, the peas shelled, and the pods weighed.

TABLE 1.—DIAMETERS AND VOLUMES OF DIFFERENT SIEVE SIZES OF PEAS.

SIEVE SIZE NO.	DIAMETER OF OPENINGS OF SIEVE IN		ASSUMED DIAMETER OF SINGLE PEA IN		CALCULATED AVERAGE VOLUME OF SINGLE PEA, CC
	32d inch	cm	32d inch	cm	
1 passes thru	9	0.714	8.5	0.678	0.1620
2 passes thru	10	0.794	9.5	0.754	0.2245
3 passes thru	11	0.873	10.5	0.833	0.3027
4 passes thru	12	0.952	11.5	0.913	0.3982
5 passes thru	13	1.032	12.5	0.992	0.5111
6 stays on...	13	1.032	13.5	1.072	0.6450

As soon as the sample could be shelled, it was passed thru a set of hand sieves which separated it into the usual sizes 1 to 6, the diameters of which appear in Table 1. Table 1 also includes the calculated volume of an average single pea that passes the various sieves. The total weight of peas in grams and the number of peas in 100 grams in each sieve size were then determined. All these studies of the samples were finished within 3 hours of pulling the plants.

The peas in the 50-plant sample previously mentioned were treated in the same manner, except that the number of peas instead of the

weight in each sieve size was determined. In addition to these two sets of samples, the peas from the square-yard plats that were tagged at blossoming time were harvested and treated like the 50-plant samples. In the case of these samples, the plants from the three plats in each area were taken one plat at a time on three different dates during the harvest season, thus giving three harvests of peas of different known ages for study.

In studying the enlargement of the peas, two factors were calculated from the data, *viz.*, the average sieve size of the pea population and the volume of an average single pea. The average sieve size was calculated from Boswell's[6] number or maturity index, called MI previously,[7] by dividing that number by 100. Average sieve size is used here because it is more easily comprehensible than MI. This average sieve size was determined from the weight of peas for the 6-square-yard samples and from the number of peas in the various sizes for the 50-plant and tagged samples. The volume of a single pea was easily calculated from the constants in Table 1 for the 50-plant and tagged samples because the number of peas was known, but for the 6-square-yard samples it was necessary to use the factor for the number of peas in 100 grams of the various sizes for all the harvest dates.

PRESENTATION OF RESULTS

1931 SEASON

The abnormal enlargement of peas from plants affected with root-rot was first observed in 1931 by Horsfall, Kertesz, and Green. Table 2 summarizes the data obtained that year on three varieties of cannery peas, Alaska, Advancer, and Perfection. The curves for the average sieve size plotted from these data on the three varieties appear in Fig. 1.

The abnormal enlargement of the diseased peas in all three varieties was most noticeable during the early part of growth. It was characteristic for 1931 that the increase in the average sieve size of the diseased peas stopped before the normal peas attained their maximum growth. The growth of the diseased peas for all three varieties always seemed to exceed that of the normal samples until they reached average sieve size 3. Above average sieve size 3, the normal peas enlarged more rapidly than did the diseased peas. This waning in the growth rate of the diseased peas as shown by the average sieve

[6]Boswell, V. R. Factors influencing yield and quality of peas—biophysical and biochemical studies. *Maryland Agr. Exp. Sta. Bul. No. 306, 341–382. 1929.*

[7]See footnote 2.

size may not be due entirely to the lack of growth of the smaller sizes of peas but to some extent to the premature shrinkage due to drying of the peas, particularly of the larger sizes.

The premature drying and shrinkage of the diseased peas in 1931 that resulted in their being smaller than normal peas at the end of the

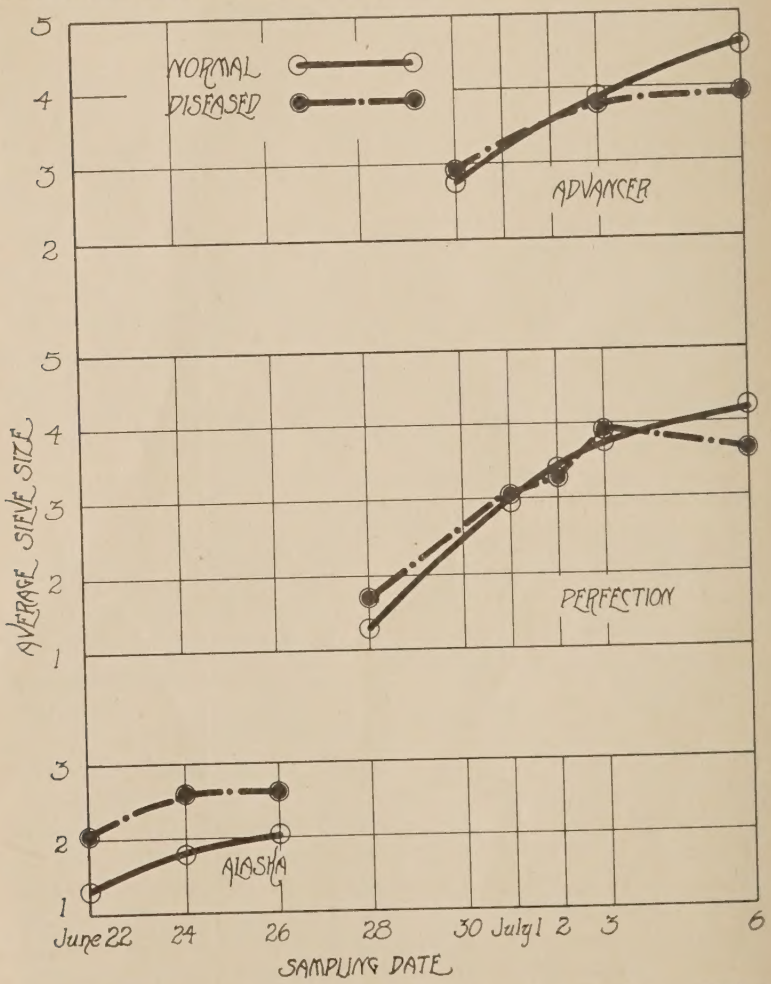

FIG. 1.—GROWTH RATE OF NORMAL AND ROOT-ROT-AFFECTED PEAS IN 1931 AS SHOWN BY THE AVERAGE SIEVE SIZE.

The diseased peas were always larger than normal during the early stages of growth.

season was due, no doubt, to the failure of the diseased roots to supply sufficient water. This situation was aggravated in 1931 by a severe drought during pea harvest.

TABLE 2.—COMPARATIVE ENLARGEMENT OF NORMAL AND DISEASED PEAS OF DIFFERENT VARIETIES IN 1931.

DATE OF SAMPLING	AVERAGE SIEVE SIZE	
	Normal peas	Diseased peas
Alaska		
June 22	1.30	2.03
June 24	1.81	2.58
June 26	2.03	2.62
Advancer		
June 30	2.74	2.88
July 3	3.90	3.78
July 6	4.56	3.93
Perfection		
June 28	1.26	1.68
July 1	2.94	3.02
July 2	3.40	3.31
July 3	3.75	3.91
July 6	4.24	3.62

This shrinkage was noticeable also in the samples taken during the 1932 season, but in that year it seemed to occur equally in both samples. Attention should be called to the fact that a heavy rain (0.99 inch) on July 2, 1931, raised the average sieve size of the diseased Perfection peas above that of the normal peas, in spite of the fact that it had previously fallen below. This indicates that the shrinkage was really due to drying and that it was not wholly irreversible.

1932 SEASON

During 1932, the abnormal enlargement of the diseased peas observed during 1931 was confirmed by several methods. In the latter year, however, the diseased peas remained almost consistently larger than the normal ones during the entire season instead of only thru the early growth period as in 1931.

Table 3 contains the data on the average sieve size of the pea population and the volume of a single pea in normal and diseased Perfection peas harvested from contiguous 6-square-yard areas on different dates.

The curve for the *average sieve size* plotted from these data appears in Fig. 2, where it is obvious that the diseased peas were larger than normal on any harvest date except July 1 when they were of equal size. The curves for *volume* of a single normal and diseased pea ap-

TABLE 3.—VOLUME OF NORMAL AND DISEASED PERFECTION PEAS

SIEVE SIZE No.	JUNE 27		JUNE 29		July 1		JULY 3	
	Distribution of sizes, per ct.*	Volume, cc	Distribution of sizes, per ct.*	Volume, cc	Distribution of sizes, per ct.*	Volume, cc	Distribution of sizes, per ct.*	Volume, cc
				Normal Peas				
1	78.0	104.98	36.6	49.25	11.2	14.90	4.9	7.13
2	17.5	19.16	29.6	21.26	17.5	17.55	7.5	7.45
3	4.5	4.54	18.1	19.02	27.7	27.10	13.1	13.32
4	0.0	0.00	12.2	13.55	26.5	27.18	27.1	18.50
5	0.0	0.00	3.5	4.86	15.4	16.46	38.1	40.12
6	0.0	0.00	0.0	0.00	2.0	2.26	8.4	9.35
Volume av. pea		0.17		0.214		0.290		0.371
Av. sieve size		1.27		2.06		3.23		4.08
				Diseased Peas				
1	59.1	79.70	22.4	30.13	15.3	19.12	4.3	5.78
2	27.0	27.40	33.3	33.25	19.1	20.20	8.6	8.83
3	10.3	11.20	27.7	28.18	20.9	19.97	10.2	10.53
4	3.6	4.62	13.8	14.75	20.4	19.85	23.6	25.20
5	0.0	0.00	2.8	3.53	21.6	22.73	40.8	43.35
6	0.0	0.00	0.0	0.00	2.7	2.13	12.6	14.57
Volume av. pea		0.186		0.233		0.280		0.396
Av. sieve size		1.58		2.41		3.23		4.31

*On weight basis.

pear in Fig. 3. The method of calculating the data for the curve in Fig. 3 is wholly different from that used for Fig. 2, and yet both methods give essentially the same results, i. e., the average diseased pea is larger than the normal pea on all harvest dates except July 1. The agreement between the results calculated in these two ways is rather noteworthy.

Since the peas taken from the 50-plant samples used for disease readings were sifted the data are included here because the average sieve size was calculated directly from the number and not from the weight of peas in each sieve size. These samples were composites from the whole infested or normal areas and not from small portions; but, on the other hand, they were taken from only 50 plants instead of from about 400 as in the previous samples. The data are given in Table 4 and appear graphically in Fig. 4. Considering the method of sampling, the curves shown in Fig. 4 conform very closely for June 29 and July 6 with those in Fig. 3; but on July 13, the diseased peas were smaller than the normal peas. No good explanation is available for this, except

HARVESTED FROM 6 SQUARE YARDS ON DIFFERENT DATES IN 1932.

JULY 5		JULY 7		JULY 9		JULY 12		JULY 15	
Distribution of sizes, per ct.*	Volume, cc	Distribution of sizes, per ct.*	Volume, cc	Distribution of sizes, per ct.*	Volume, cc	Distribution of sizes, per ct.*	Volume, cc	Distribution of sizes, per ct.*	Volume, cc
				Normal Peas					
3.3	4.49	1.9	2.56	0.9	1.22	0.5	0.70	0.0	0.00
2.1	2.13	2.1	2.11	1.1	1.19	0.2	0.25	1.2	1.26
9.9	9.99	4.2	4.24	2.1	2.21	0.9	1.06	2.1	2.39
14.4	15.26	9.3	9.71	7.7	8.24	5.7	5.69	9.2	9.92
36.8	38.40	27.5	30.35	27.2	28.93	24.9	26.70	33.8	35.57
33.5	35.40	55.0	54.60	61.0	65.30	67.8	68.90	53.7	58.20
	0.443		0.504		0.539		0.567		0.542
	4.80		5.23		5.42		5.57		5.37
				Diseased Peas					
2.9	3.95	1.3	2.53	0.7	1.10	0.0	0.00	0.0	0.00
3.9	4.04	1.7	1.76	0.6	0.62	0.4	0.40	0.6	0.67
5.4	5.57	2.9	2.87	1.2	1.21	1.0	1.00	1.8	1.85
14.0	14.50	6.9	7.20	7.1	7.25	3.6	3.63	7.6	7.76
34.2	36.90	27.6	27.78	20.4	21.26	27.5	28.10	32.5	34.55
39.6	42.90	59.6	63.00	70.0	80.61	67.6	69.85	57.5	61.60
	0.457		0.515		0.568		0.580		0.555
	4.91		5.37		5.56		5.61		5.41

that the diseased plants on that day were inferior in all respects to the diseased plants harvested on the other two days. The July 13 diseased sample, therefore, did not appear to be a random sample.

Another approach to the problem was to determine the volume of peas of known age to see if diseased peas grew more rapidly than normal peas. Accordingly, a large number of blossoms were tagged on different dates during the blooming period. Three sets of harvests were made of these tagged samples, *viz.*, on June 29, on July 2, and on July 6. The data from the harvest of the tagged samples appear in Tables 5 and 6 and are shown graphically in Fig. 5. The curves in Fig. 5 show clearly that the young diseased peas as represented by the June 29 sample are larger than normal peas of the same age. The same is generally true for the older peas harvested on July 2 and July 6, altho the progressive shrinkage of peas influenced the shape of the curves considerably. In spite of this fact, however, there is one point of much importance which should be mentioned. It is obvious from the sets of peas harvested on the three harvest dates that peas of the

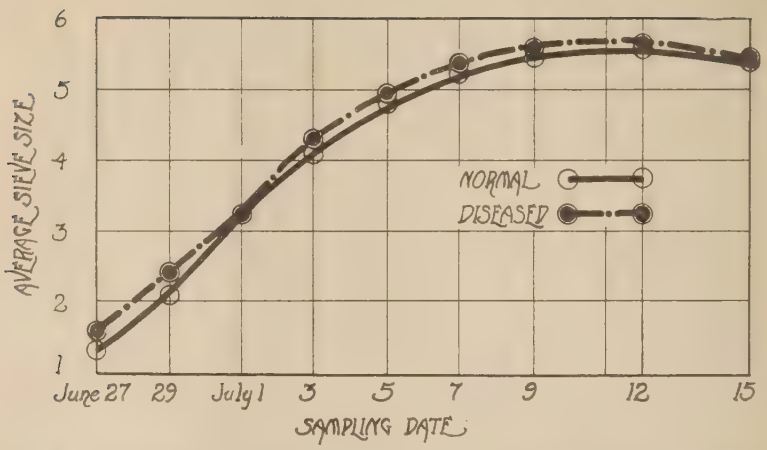

FIG. 2.—GROWTH RATE OF NORMAL AND ROOT-ROT-AFFECTED PERFECTION PEAS IN A 400-PLANT SAMPLE IN 1932 AS SHOWN BY THE AVERAGE SIEVE SIZE.

Except for July 1, the diseased peas were always larger than normal, even during the beginning of the shriveling period incident to maturation.

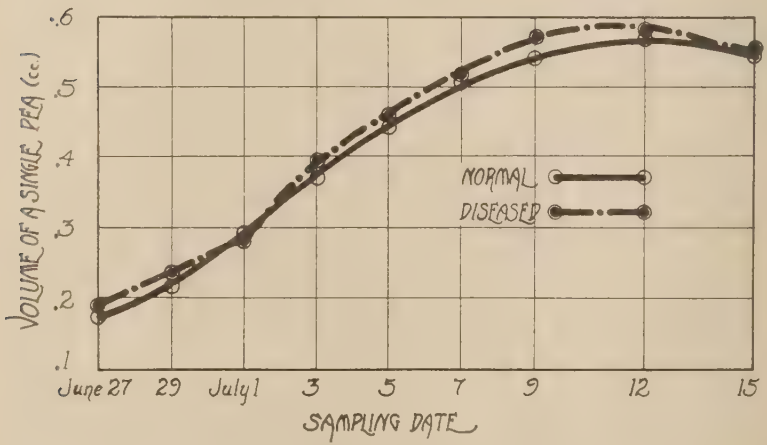

FIG. 3.—GROWTH RATE OF NORMAL AND ROOT-ROT-AFFECTED PERFECTION PEAS IN A 400-PLANT SAMPLE IN 1932 AS SHOWN BY THE VOLUME OF AN AVERAGE SINGLE PEA BASED UPON WEIGHT OF PEAS OF KNOWN AVERAGE VOLUME.

Using this method of calculation, it is shown that diseased peas were larger than normal peas, except on July 1.

TABLE 4. VOLUME OF NORMAL AND DISEASED PERFECTION PEAS HARVESTED FROM 50 PLANTS ON DIFFERENT DAYS IN 1932.

	VOLUME IN CC IN SIEVE SIZE NO.						TOTAL VOLUME, CC	TOTAL NO. OF PEAS	AVERAGE SIEVE SIZE	VOLUME OF AVERAGE PEA, CC
	1	2	3	4	6	5				
Harvested June 30										
Normal	58.32	27.17	45.10	30.25	8.69	0.00	169.54	723	2.08	0.235
Diseased	34.83	28.74	45.41	39.82	20.96	5.01	175.56	643	2.60	0.273
Harvested July 6										
Normal	17.01	12.35	39.35	58.54	121.13	117.52	365.90	850	4.18	0.431
Diseased	3.73	3.14	11.81	43.90	105.80	143.84	312.21	614	4.98	0.509
Harvested July 13										
Normal	6.34	4.25	7.27	25.09	140.04	353.33	540.29	973	5.25	0.555
Diseased	4.03	0.89	2.72	25.49	114.49	128.36	275.97	525	5.00	0.526

same age in number of days from blooming are not of the same size. Peas blooming later grow more slowly and seem to attain a larger average sieve size and volume of an average single pea before the onset of shriveling. It is rather remarkable that in spite of this variation in the size of peas which reach the same age on different dates, the root-rot-affected peas proved to be larger at all ages of the first and in most cases of the second and third harvest. It seems, then,

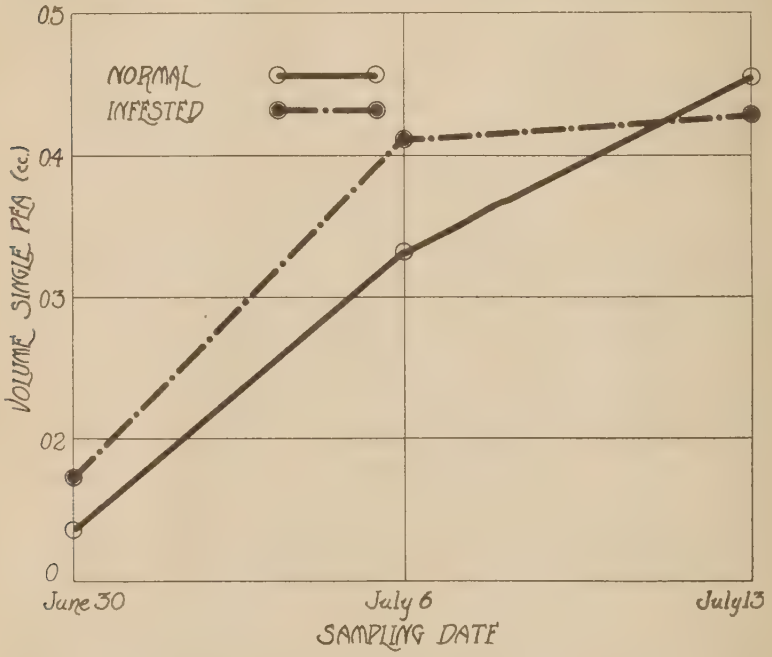

FIG. 4.—GROWTH RATE OF PERFECTION PEAS IN A 50-PLANT SAMPLE FROM NORMAL AND ROOT-ROT-INFESTED SOIL IN 1932, AS SHOWN BY THE VOLUME OF AN AVERAGE SINGLE PEA BASED UPON NUMBER OF PEAS OF KNOWN AVERAGE VOLUME.

that the peas of the root-rot-affected samples were less affected by this unknown factor causing slower growth than were the peas in the normal samples.

It was of considerable importance in this work to obtain some information regarding the actual blooming of the peas in the normal and infested parts of the field. In case it could be proved that the blooming occurred earlier in the diseased part of the field, this fact

TABLE 5.—VOLUME IN CC OF NORMAL PERFECTION PEAS OF KNOWN AGE HARVESTED ON DIFFERENT DATES IN 1932.

Blooming date, June	13	14	15	16	17	18	19	20	21	22	23	24	26
Harvested June 29													
Age in days	16	15	14	13	12	11	10	9	8	7	6	5	3
Sieve size No. 1	0.000	0.000	0.162	1.782	3.402	29.160	15.066	19.926	0.000	0.000	0.000	0.000	0.000
Sieve size No. 2	0.225	0.000	2.250	16.200	7.640	4.450	0.675	0.000	0.000	0.000	0.000	0.000	0.000
Sieve size No. 3	0.908	1.210	10.900	18.500	0.605	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sieve size No. 4	1.596	3.190	10.000	3.190	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sieve size No. 5	2.050	0.000	0.000	0.511	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Volume of av. pea	0.395	0.367	0.324	0.263	0.204	0.168	0.164	0.162	0.000	0.000	0.000	0.000	**0.000**
Av. sieve size	3.92	3.14	3.18	2.45	1.67	1.20	1.03	1.00	0.00	0.00	0.00	0.00	0.00
Harvested July 2													
Age in days	19	18	17	16	15	14	13	12	11	10	9	8	6
Sieve size No. 1	0.000	0.810	1.134	0.324	4.212	3.888	21.060	52.812	9.558	3.564	0.000	0.000	0.000
Sieve size No. 2	0.000	0.000	0.225	0.449	2.470	24.250	28.500	10.550	2.020	0.000	0.000	0.000	0.000
Sieve size No. 3	0.000	0.000	1.512	8.470	25.700	38.100	9.080	2.120	3.330	0.000	0.000	0.000	0.000
Sieve size No. 4	1.992	0.796	6.770	56.600	38.600	19.920	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sieve size No. 5	0.000	0.000	23.000	51.100	15.350	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sieve size No. 6	0.000	0.000	0.000	1.935	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Volume of av. pea	0.398	0.229	0.435	0.492	0.347	0.280	0.204	0.172	0.189	0.162	0.000	0.000	0.000
Av. sieve size	4.00	1.86	4.00	4.25	3.38	2.66	1.65	1.16	1.39	1.00	0.00	0.00	0.00
Harvested July 6													
Age in days	23	22	21	20	19	18	17	16	15	14	13	12	10
Sieve size No. 1	0.000	0.162	1.620	0.000	0.486	0.000	5.346	5.184	1.296	2.754	2.106	1.134	0.972
Sieve size No. 2	0.000	0.000	0.450	0.000	0.000	0.000	0.225	6.960	0.000	0.000	0.000	0.000	0.000
Sieve size No. 3	0.000	0.909	0.303	0.000	0.000	1.210	1.816	17.850	2.420	0.000	0.909	0.303	0.000
Sivee size No. 4	0.000	2.790	3.590	2.390	4.780	19.130	21.100	15.150	0.398	0.000	1.595	0.398	0.000
Sieve size No. 5	0.000	3.580	2.045	18.420	31.700	36.830	22.000	3.580	0.511	0.511	0.000	0.000	0.000
Sieve size No. 6	0.000	3.870	20.640	59.400	51.600	25.800	4.520	3.870	0.000	0.000	0.000	0.000	0.000
Volume of av. pea	0.000	0.471	0.494	0.599	0.564	0.506	0.385	0.304	0.246	0.192	0.229	0.208	0.187
Av. sieve size	0.00	4.59	4.57	5.64	5.36	4.90	3.65	2.86	2.18	1.42	1.92	1.63	1.40

TABLE 6.—VOLUME IN CC OF DISEASED PERFECTION PEAS OF KNOWN AGE HARVESTED ON DIFFERENT DATES IN 1932.

Blooming date, June	13	14	15	16	17	18	19	20	21	22	23	24	26
Harvested June 29													
Age in days	16	15	14	13	12	11	10	9	8	7	6	5	3
Sieve size No. 1	0.000	0.000	0.162	3.078	3.041	10.530	18.792	0.000	0.000	0.000	0.000	0.000	0.000
Sieve size No. 2	0.000	0.225	0.225	6.750	13.500	12.570	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sieve size No. 3	0.000	0.908	2.120	18.160	8.170	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sieve size No. 4	0.000	0.797	7.570	5.980	3.190	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sieve size No. 5	0.000	3.070	4.600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Volume av. pea	0.000	0.417	0.397	0.274	0.244	0.191	0.162	0.000	0.000	0.000	0.000	0.000	0.000
Av. sieve size	0.00	4.08	3.92	2.57	2.19	1.46	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Harvested July 2													
Age in days	19	18	17	16	15	14	13	12	11	10	9	8	6
Sieve size No. 1	0.000	0.000	0.000	1.620	1.782	2.430	0.518	0.000	0.000	0.000	0.000	0.000	0.000
Sieve size No. 2	0.000	0.000	0.000	0.225	1.572	7.630	6.290	5.390	0.000	0.000	0.000	0.000	0.000
Sieve size No. 3	0.000	0.303	0.000	6.660	7.260	13.000	6.350	1.210	0.000	0.000	0.000	0.000	0.000
Sieve size No. 4	0.000	1.992	1.992	46.600	20.700	14.340	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sieve size No. 5	0.000	0.000	12.800	36.800	13.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sieve size No. 6	0.000	0.000	8.380	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	000.0
Volume av. pea	0.000	0.383	0.539	0.414	0.372	0.292	0.258	0.196	0.000	0.000	0.000	0.000	0.000
Av. sieve size	0.00	3.83	5.19	4.08	3.63	2.78	2.43	1.53	0.00	0.00	0.00	0.00	0.00
Harvested July 6													
Age in days	23	22	21	20	19	18	17	16	15	14	13	12	10
Sieve size No. 1	0.000	0.000	0.972	0.324	0.648	0.486	1.458	2.106	0.486	1.296	6.318	3.564	0.324
Sieve size No. 2	0.000	0.000	0.900	0.450	0.000	0.225	0.000	2.470	1 350	3.820	1.570	1.800	0.000
Sieve size No. 3	0.000	0.000	0.909	0.000	0.000	1.816	0.303	15.730	2.118	5.140	3.030	1.210	0.000
Sieve size No. 4	0.000	0.000	0.000	2.790	1 200	11.165	11.560	23.100	1.595	0.797	0.000	0.000	0.000
Sieve size No. 5	0.000	0.000	0.000	20.450	15.850	26.560	32.200	11.760	2.045	0.000	0.000	0.000	0.000
Sieve size No. 6	0.000	0.000	2.580	47.720	26.450	7.095	7.120	1.940	0.000	0.000	0.000	0.000	0.000
Volume av. pea	0.000	0.000	0.315	0.574	0.559	0.469	0.466	0.357	0.316	0.251	0.195	0.193	0.162
Av. sieve size	0.00	0.00	2.77	5.42	5.28	4.57	4.51	3.48	3.25	2.30	1.48	1.47	1.00

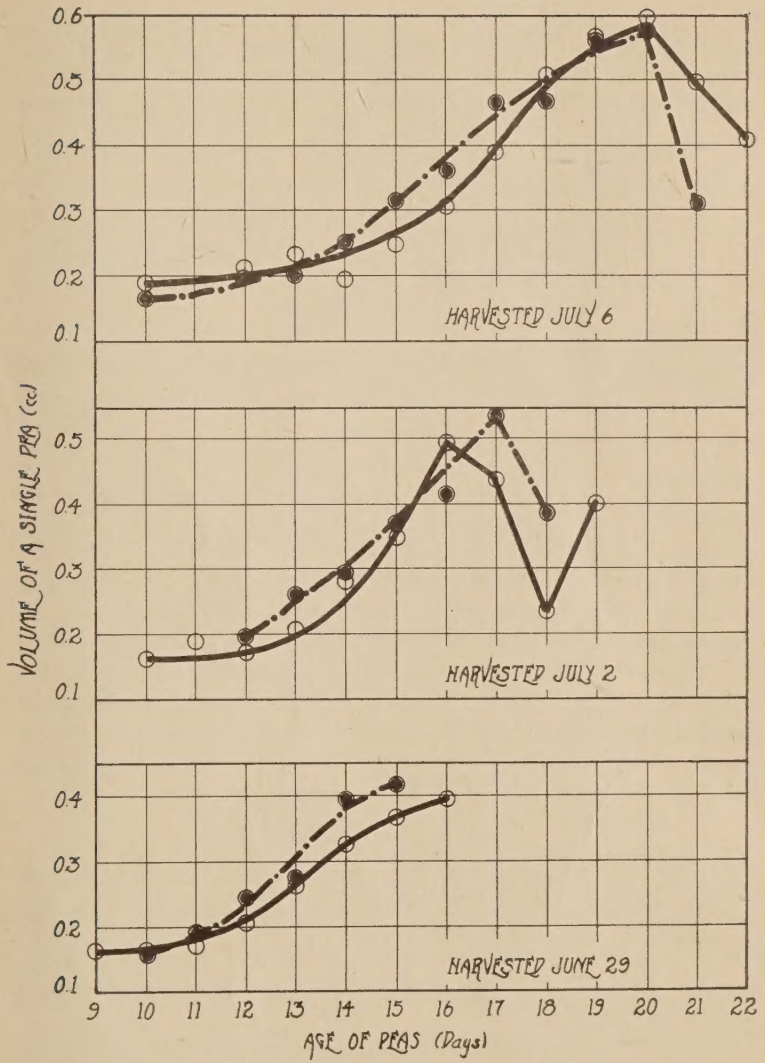

FIG. 5.—GROWTH RATE OF NORMAL AND ROOT-ROT-AFFECTED PERFECTION PEAS FROM TAGGED BLOSSOMS OF KNOWN BLOOMING DATE AND HENCE FROM PODS OF KNOWN AGE, BUT HARVESTED ON DIFFERENT DATES.

This supports the general thesis that blooming date has little influence in producing diseased peas bigger than normal.

would explain, partly at least, why the samples taken from pods of unknown age in an ordinary harvesting are larger. Table 7 and Fig. 6 show the rate of blooming observed in the same plat of Perfection peas from which all the 1932 samples were obtained. The number of

TABLE 7.—THE RATE OF BLOOMING OF NORMAL AND DISEASED PERFECTION PEAS IN 1932.

	BLOOMING DATE, JUNE												
	13	14	15	16	17	18	19	20	21	22	23	24	26
Normal Peas													
Number blooms per plant	0.01	0.03	0.14	0.41	0.23	0.57	0.51	0.85	0.24	0.33	0.20	0.14	0.09
Increment per plant	—	0.04	0.18	0.59	0.82	1.39	1.90	2.75	2.99	3.32	3.52	3.66	3.75
Diseased Peas													
Number blooms per plant	0.00	0.01	0.08	0.38	0.26	0.31	0.34	0.70	0.01	0.02	0.02	0.02	0.01
Increment per plant	—	0.01	0.09	0.47	0.73	1.04	1.38	2.08	2.09	2.11	2.13	2.15	2.16

blooms per diseased plant was smaller than per normal plant thruout the season. The blooming progressed more slowly, however, in the infested section of the field, and had stopped almost entirely by June 20. When the "average blooming date" was calculated, only about a half day difference to the advantage of the diseased peas could be found. This difference is by no means large enough to be greatly responsible for the abnormal enlargement of the diseased peas, even if the significance of this earlier blooming could be proved.

PRACTICAL ASPECTS

For many years consumers have believed that peas of any given variety that are larger than average are of poorer quality than average sized peas of the same variety. This belief was reflected a few years ago in the development of varieties of small-seeded types of peas. More recently, however, the tendency has been toward big peas of good quality.

The fact as reported in this bulletin that peas from root-rot-affected plants are bigger than peas from normal plants of equal age and history is offered as a partial explanation of the origin and rise of the common dislike for big peas. All observant pea growers and canners know, of course, that diseased peas are poorer in quality, i. e., tougher than normal peas and disagreeable in taste. A report dealing with

the chemical relations of the poor quality in peas from diseased plants is now being prepared by the authors.

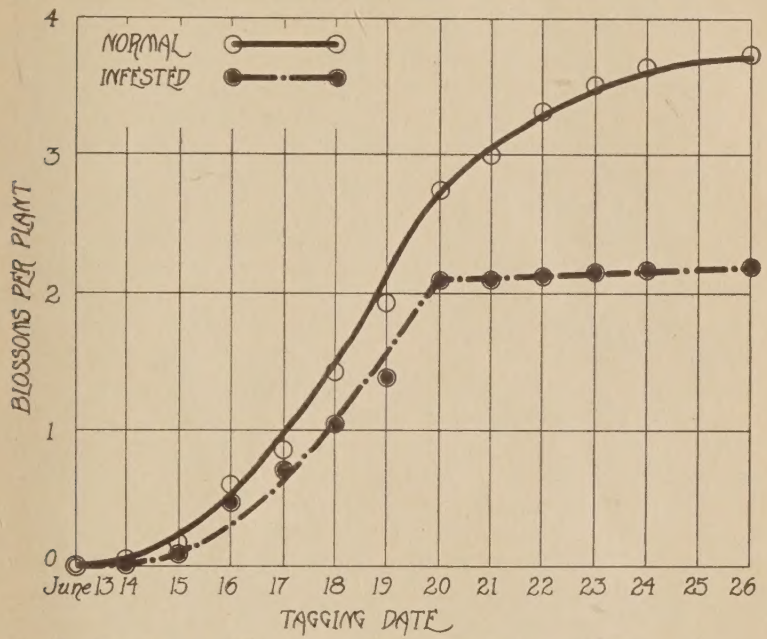

FIG. 6.—THE RATE OF BLOOMING OF PERFECTION PEAS ON NORMAL AND ROOT-ROT-INFESTED SOIL IN 1932.

DISCUSSION AND CONCLUSIONS

The object of this bulletin was to endeavor to establish by different methods the fact that diseased peas grow larger than normal peas rather than to advance a theoretical explanation of the phenomenon. Certain facts bearing on an explanation have been set down, however.

In determining the size of the peas in the samples, the harvested peas were sifted in all cases. For the 1931 samples, the average sieve size was calculated on the basis of the weight of peas in the different fractions. In 1932, this method was used again, but the same peas were also used to establish differences on the basis of the number of peas in the fraction.

From the results of the two seasons it appears that, as long as a plentiful supply of water remains in the soil, as in 1932, diseased peas grow larger and remain larger than normal peas, even tho they

are of equal age in number of days from blossoming. When the soil moisture content falls below a point where the diseased roots can absorb it easily, then peas on diseased vines shrivel prematurely and become smaller in size than peas on normal vines. If shriveling does not progress too far, a rain will be reflected in a re-enlargement of the peas.

Having determined that disease induces an abnormal enlargement of the peas, it was illuminating to calculate the average sieve size of peas on plants that had been protected from root-rot by soil treatment as contrasted with peas from neighboring untreated plants. In 1930, a partial alleviation of the root-rot symptoms on Alaska peas was obtained by treating the soil with aluminum sulfate. Three treated and three untreated 1/50 acre plats were harvested and vined by machinery, as contrasted with hand shelling. The average sieve size (on weight basis) of peas from the treated plants was 2.34, whereas that for the untreated plants was 2.80. Thus, pertinent data from experiments performed before these enlargement studies were begun, corroborate the conclusion that diseased peas are larger than normal peas.

It seems clear from the 1932 tests that the abnormal enlargement of the root-rot-affected peas cannot be due to any great extent to earlier blooming because blooming in the normal and infested areas began on the same date. Because of a somewhat abrupt and early ending to the blooming period of the diseased peas, the average blooming date was advanced about one-half day; but even if that advance were significant, it can have but little bearing on an explanation of why peas from diseased plants are larger than those from normal plants.

Furthermore, the data indicate that peas on diseased vines have a higher growth rate than those on normal plants because they attain a given size earlier even when they bloom on the same day.

One other noteworthy fact brought out by this study is that peas, both diseased and normal, which came from late blooms in 1932 grew more slowly, altho to a larger size, than those from early blooms. In spite of this differential growth rate due to blooming date, the growth rate of the diseased peas was more rapid than that of the normal peas.

Since diseased peas are big peas, it seems probable that disease may account for a part of the common belief that big peas are poor peas. Canners generally are now inclined to believe that a big pea of good quality is more desirable than a small pea of the same quality. Possibly root-rot offers a partial explanation of why it is sometimes difficult to obtain good quality in the big sizes.